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WORK PHASE DETERMINATION FOR MACHINE TOOLS, AND DEVICE THEREFOR

FIELD OF THE INVENTION

This invention relates to a work phase determination method for machine tools and a device therefore.

BACKGROUND OF THE INVENTION

There is a machine tool in which a spindle housing supporting a specifically directed spindle for rotation alone is supported for parallel motion in orthogonal three-axis directions XYZ by a numerical control mechanism (see, for example, Japanese Patent Publication No. 2001-9652).

In the machine tool, a work support-feeding device that feed-rotates a work around a specific axis is provided, and machining is carried out by feed-rotating the work at a specific angle position therearound.

To perform such a machining, it is necessary to accurately determine a phase for the work around the specific axis on the work support-feeding device. Therefor, a reference tool for phase determination is formed and installed to the spindle, and thereon, a phase determination operation is performed so as to abut the work. After the operation, the tool is detached from the spindle and stored in a specific position. (See, for example, Japanese Patent No. 3083776.)

In the above-mentioned conventional work phase determination method, working efficiency falls because the operation of mounting/dismounting the reference tool on the spindle is required. In addition, it is uneconomical because a storage space for the reference tool is required. Moreover, there is some fear for shortening a bearing life because a load acts on a bearing rotation-freely supporting the spindle when the work abuts against the reference tool.

The present invention aims to settle the above-mentioned problems.

SUMMARY OF THE INVENTION

To achieve the above-mentioned aims, in the present first invention, in a machine tool in which a spindle housing supporting the specifically directed spindle for rotation alone is supported for parallel motion in orthogonal three-axis directions XYZ by a numerical control mechanism, in determining the phase for the work to be feed-rotated around a specific axis, it is arranged that with a reference block fixed to the spindle housing, the work is feed-rotated around the specific axis to abut the phase reference section of the work against the reference block, so as to find the amount of feed-rotation (a phase angle θ of a chuck part) of the work at the time of this abutment.

In this invention, the reference block remains being fixed on the spindle housing, and such a construction can be simple and inexpensive. In addition, when operating so as to decide a phase around the specific axis of the work, an enforcing power isn't given from the work to the spindle. Accordingly, the bearing life for rotation-freely supporting the spindle can be prolonged.

More specifically, in the machine tool in which the spindle housing supporting the specifically directed spindle for rotation alone is supported for parallel motion in orthogonal three-axis directions XYZ by the numerical control mechanism, in determining the phase for the work to be feed-rotated around the specific axis, it is arranged that the reference block including a first plane perpendicular to a direction of the spindle and a second plane parallel to both of the direction of the spindle and the specific axis is fixed to the spindle housing, and the work is normally or reversely feed-rotated around the specific axis to abut the phase reference section of the work against each of the first plane and the second plane, so as to find the amount of feed-rotation (phase angles $\theta 1$, $\theta 2$ of the chuck part) of the work at the time of the abutments.

In this invention, the following effect can be given in addition to the above-mentioned effects. That is, the determination of a phase for the work around the specific axis by using the first plane and the second plane improves the accuracy of the determination thereof.

In these inventions, a crankshaft is suitable for the work, and in this case, a crank

pin can be used as the phase reference section. According to this, the above-mentioned effects can be given in the determination of the phase for crankshaft, and besides, using the crank pin for the phase reference section can dispense with preparing a special phase reference section.

In the present second invention, in a machine tool in which a spindle housing supporting a specifically directed spindle for rotation alone is supported for parallel motion in orthogonal three-axis directions XYZ by a numerical control mechanism, a reference block in which a phase reference section of a work feed-rotated around a specific axis by the numerical control mechanism abuts is fixed on the reference block. This invention contributes to carrying out the first invention.

More specifically, in the machine tool in which the spindle housing supporting the specifically directed spindle for rotation alone is supported for parallel motion in orthogonal three-axis directions XYZ by the numerical control mechanism, the reference block is fixed on the spindle housing, whereas a work support-feeding device for feed-rotating the work around the specific axis perpendicular to the direction of the spindle, and a work phase deciding means for determining a phase for the work around the specific axis based on the amount of feed-rotation around it when the phase reference section feed-rotated around it abuts against the reference block displaced to a phase adjustment position with reference to the work in advance is provided. This invention contributes to understanding the amount of feed-rotation of the work by reciprocally rotating the work around the specific axis.

The reference block of the second invention is constructed so as to include at least either of a first plane and a second plane. Here, the first plane is perpendicular to the direction of the spindle and abutted to the phase reference section, and the second plane is parallel to the direction of the spindle and the specific axis, respectively.

In this invention, the phase for the work around the specific axis is determined by abutting the phase reference section of the work to either of the first plane and the second plane. Besides, when the phase reference section of the work is abutted to both of the first plane and the second plane, the phase for the work around the specific axis

can be decided accurately regardless of an error in its finishing dimension.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view of a machine tool of the present invention, in which a part is shown in a section.

Fig. 2 is a plane view of the machine tool, and Fig. 3 is a view showing a section taken on line X1-X1 in Fig. 2.

Fig. 4 is a view showing an operating flow sheet of the present invention, and Fig. 5 is a view showing an operating flow sheet next to the operating flow sheet in Fig 4.

Fig. 6 is an explanatory view showing a situation that a crank pin is abutted to the first plane of a reference block of the machine tool. Fig.7 is an explanatory view showing a situation that a crank pin is abutted to the second plane of the reference block. Fig. 8 is an explanatory view of a modification concerning a phase adjustment position of the reference block.

PREFERRED EMBODIMENT OF THE PRESENT INVENTION

An explanation about the present invention will follow with reference to figures.

In Figs. 1 to 3, 1 is a bed, and thereon, are provided a fixed column 2, a work support-feeding device 3, a numerical control mechanism 4 and hydropneumatic equipment 5.

A cylindrical spindle housing 7 rotation-freely supporting a longitudinally directed spindle 6 (in a Z-axis direction) is mounted to the fixed column 2 feed-displaceably in an X-axis direction, a Y-axis direction and the Z-axis direction forming orthogonal three-axis directions. A cutting tool 8 is fixed to a front end of the spindle 6.

A reference block 9 is forward-protrudently fixed to the lowest position of a front outer peripheral face of the spindle housing 7 below the spindle 6. The reference block 9 comprises a front face 9a and a lower end face 9b. Here, the front face 9a forms a first plane perpendicular to the Z-axis direction, and the lower end face 9b forms a

exactly. In addition, at the same time, one end face of the work w is pushed to a work longitudinal reference face 18b formed near the center of the chuck portion 18 and perpendicular to the specific axis S, and the position on the specific axis S direction is fixed. Under the situation, the claws 18a clamp the outer periphery of one end of the work w.

Thereafter, in step S103, the program for determining a phase is started. The numerical control mechanism 4 displaces the spindle housing to the predetermined position, and the reference block 9 is displaced and stopped to the phase adjustment position p2. In the displaced reference block 9, the center on the X-axis direction is positioned at the about center of the length of a specified crank pin w1. Besides, as shown in Fig.6, an intersection point p3 between the first plane 9a and the second plane 9b is turned to a radial direction of the specific axis S and situated on the Z-axis and the Y-axis to be positioned on a line L1 inclined in right rise by 45° against these axes. Moreover, the first plane 9a and the second plane 9b are respectively positioned on a rotation displacement locus of the crank pin w1 around the specific axis S. Besides, the phase adjustment position p2 showing an example can be exchanged to another position suitably. This will be described later in detail.

Next, in step S104, the NC table 16 is operated to feed-rotate the work w in a normal rotation direction around the specific axis S with the chuck portion 18. When the crank pin w1 abuts to the first plane 9a of the reference block 9 as shown in Fig. 6, the detection is performed to stop the NC table 16 from operating. In this case, the rotation angle θ 1 of the chuck portion 18 at the time of this abutment is recognized and memorialized in the numerical control mechanism 4. The rotation angle θ 1 is an angle from the table phase reference p0 to the phase zero position reference k1 of the chuck portion 18 at the time of the abutment.

In this case, the abutment between the crank pin w1 and the first plane 9a is detected directly by a torque sensor when torque transmitted from the work drive portion 14 to the chuck portion 18 increases or indirectly by a drive amperometry of the work drive portion 14.

Next, in step S105, it is discriminated whether a high-accurate operation will be required in the operation of determining the phase for the work. In this case, the standard for discrimination depends on the operator's optional will.

When it is decided that the high-accurate operation is unnecessary, the process is displaced to step S106, whereas when it is decided that the operation is necessary, the process is displaced to step 107.

In the step S106, the rotation angle of the work w in after adjusting the phase is corrected in accordance with the rotation angle θ 1 of the chuck portion 18 at the time of the abutment between the reference block 9 and the crank pin w1.

Fully, the rotation angle θ 1 is calculated by data such as a rotation radius around the specific axis S at the center of the crank pin w1, a diameter of the crank pin and position of the first plane 9a of the reference block 9. Here, the calculated rotation angle from the table phase reference p0 of the chuck portion 18 is assumed to be θ 10.

Next, the rotation angle θ 10 is deducted from the rotation angle θ 1 of the chuck portion 18 calculated in the step S104. Thus calculated difference value θ 12 agrees with the angle θ 0 from the work phase reference k2 to the phase zero position reference k1 of the chuck portion 18 if there is no machining error. And this is handled as a phase shift angle between the chuck portion 18 and the work w, and made the amount of correction in determining the phase for the work w. Accordingly, a rotation angle θ t of the chuck portion 18 for determining the phase for the work w, such as rotating the work phase reference k2 from the table phase reference p0 by a specified angle θ w only, is calculated by the following formula (1). Here, the rotation angle θ t is what the phase zero position reference k1 of the chuck portion 18 rotates from the table phase reference p0 to the normal rotation direction f1.

$$\theta t = \theta w + \theta 12 \quad \cdots\cdots\cdots \text{ Formula(1)}$$

According to the formula (1), when positioning the work w to the place of an optional specified angle θ w in the after work machining, the rotation angle θ t requires the size adding the difference value θ 12 to the angle θ w. This operation is

CLAIMS

1. In a machine tool in which a spindle housing supporting a specifically directed spindle for rotation alone is supported for parallel motion in orthogonal three-axis directions XYZ by a numerical control mechanism, in determining a phase for a work to be feed-rotated around a specific axis,

a work phase determination method for machine tools comprising:

with a reference block fixed to the spindle housing, feed-rotating the work around the specific axis,

abutting a phase reference section of the work against the reference block, and

finding the amount of feed-rotation of the work at the time of this abutment.

2. In a machine tool in which a spindle housing supporting a specifically directed spindle for rotation alone is supported for parallel motion in orthogonal three-axis directions XYZ by a numerical control mechanism, in determining a phase for a work to be feed-rotated around a specific axis,

a work phase determination method for machine tools comprising:

fixing a reference block to the spindle housing, said reference block having a first plane perpendicular to a direction of a spindle and a second plane parallel to both of the direction of the spindle and a specific axis,

feed-rotating the work normally or reversely around the specific axis,

abutting a phase reference section of the work to the first plane and the second plane, and

finding the amount of feed-rotation of the work at this abutment.

3. A work phase determination method for machine tools as set forth in claim 1 or 2,

wherein the work is a crankshaft and the phase reference section is a crank pin.

4. In a machine tool in which a spindle housing supporting a specifically directed spindle for rotation alone is supported for parallel motion in orthogonal three-axis directions XYZ by a numerical control mechanism,

a work phase determination structure for machine tools comprising:

a reference block fixed to the spindle housing so as to abut a phase reference section of the work feed-rotated around a specific axis by the numerical control mechanism.

5. In a machine tool in which a spindle housing supporting a specifically directed spindle for rotation alone is supported for parallel motion in orthogonal three-axis directions XYZ by a numerical control mechanism,

a work phase determination structure for machine tools comprising:

a reference block fixed to the spindle housing,

a work support-feeding device for feed-rotating the work around a specific axis perpendicular to a direction of the spindle, and

a work phase decision means for determining a phase of the work around the specific axis based on the amount of feed-rotation thereof when a phase reference section of the work abutting to a reference block beforehand displaced to a phase adjusting position concerned with the work.

6. A work phase determination structure for machine tools as set forth in claim 5, wherein said reference block has at least either of a first plane abutting to said phase reference section perpendicular to a direction of the spindle and a second plane abutting the phase reference section parallel to both the direction and said specific axis.